Biological Synopsis of *Garra rufa*

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2011

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2946

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Fisheries and Aquatic Sciences 2946

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by

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Cat. No. Fs 97-4/2946E ISSN 0706-6473

Correct citation for this publication:

Jarvis P.L. 2011. Biological synopsis of *Garra* rufa. Can. MS Rpt. Fish. Aquat. Sci. 2946: vi + 14p.

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ABSTRACT

Jarvis P.L. 2011. Biological synopsis of *Garra rufa*. Can. MS Rpt. Fish. Aquat. Sci. 2946: vi + 14p.

To understand the ecology of a species, it is necessary to develop a biological synopsis for the species. This document summarizes information on *Garra rufa*, a small member of the carp and minnow family (Cyprinidae) native to the Middle East. This synopsis includes *G. rufa*'s description, distribution, biology and natural history, and use by humans. There is limited knowledge available on the life history and ecological requirements of *G. rufa*, but it is found most often in lotic environments feeding on periphyton and appears to be able to tolerate a wide range of temperatures and less than pristine water quality conditions. Additionally, it spawns from late spring to summer by broadcasting over gravel type substrates and no parental care is provided to its young. To date, no individuals have been recorded outside their native range.

RÉSUMÉ

Jarvis P.L. 2011. Biological synopsis of *Garra rufa*. Can. MS Rpt. Fish. Aquat. Sci. 2946: vi + 14p.

Pour comprendre l'écologie d'une espèce, il faut effectuer une synthèse de sa biologie. Le présent document résume l'information sur *Garra rufa*, un petit poisson de la famille des carpes et des ménés (cyprinidés), qui est originaire du Moyen-Orient. Le présent synopsis donne une description de l'espèce et des renseignements sur son aire de répartition, sa biologie, son histoire naturelle et son utilisation par l'homme. On sait peu de choses sur le cycle biologique et les exigences en matière d'écologie de *G. rufa*, mais on l'observe le plus souvent dans des environnements lotiques, se nourrissant de périphyton. L'espèce semble également tolérer un vaste éventail de températures ainsi qu'une qualité d'eau moindre. En outre, elle fraie à partir de la fin du printemps jusqu'à l'été et répand les œufs sur des substrats constitués de gravier; elle ne prodigue aucun soin à sa progéniture. Jusqu'à ce jour, aucun individu n'a été observé à l'extérieur de son aire de répartition d'origine.

INTRODUCTION

Freshwater habitats and biodiversity are especially vulnerable to human activities and environmental change (see Dudgeon *et al.* 2006). The deliberate or unintentional release of non-native species has negatively affected Canadian freshwater biodiversity (Dexatrase and Mandrak 2006, Metcalfe-Smith and Cudmore-Vokey 2003).

Garra rufa is a benthoplagic, non-migratory freshwater fish indigenous to the Middle East. Most commonly referred to as "Doctor Fish", as they can feed on dead skin and hence have been used for the treatment of psoriasis and by the spa industry for pedicures (e.g., Özcelik *et al.* 2000; Grassberger and Hoch 2006). In recent years, *G. rufa* has been imported into North America for use by the spa industry and may be included in the aquarium trade. Due to the concern of intentional or accidental release of *G. rufa* into Canadian waters, the Centre of Expertise for Aquatic Risk Assessment (CEARA) has undertaken a synopsis of the species life history and ecological requirements.

NAME AND CLASSIFICATION

From Froese and Pauly (2010) and ITIS (2010):

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Cypriniformes
Family: Cyprinidae
Genus and Species: *Garra rufa* (Heckel, 1843)
Trade Name: Doctor Fish

Unambiguous Synonyms: *Discognathus crenulatus* Heckel, 1846-49; *Discognathus obtusus* Heckel, 1843; *Discognathus rufus* Heckel, 1843; *Garra rufa crenulata* Heckel, 1844; *Garra rufa gymnothorax* Berg, 1949; *Garra rufus* Heckel, 1843

DESCRIPTION

G. rufa (Figure 1) is one of the smallest members of the family Cyprinidae, and is one of about 73 members of the genus *Garra* (Coad 2010; Esmaeili *et al.* 2009). No subspecies are recognized. Although many species, both native and exotic, from the family Cyprinidae are found in Canada, no *Garra* species are known. According to Zhang (2005), *Garra* is one of four currently recognized cyprinid genera of the disc-bearing group (also *Discocheilus*, *Discogobio* and *Placocheilus* genera). This grouping is based on a lower lip modified to form a mental adhesive disc, the posterior margin of which is not continuous with the mental region. The morphology of the mental adhesive disc of the *Garra* genera is characterized by a crescentic antromedian fold that is derived from the anterior margin of the mental adhesive disc, with additional generic definition of the presence of three rows of pharyngeal teeth (Zhang 2005).

A description of *G. rufa* morphology has been compiled by Coad (2010). Briefly, a scaleless head, two pairs of barbels, a well-developed adhesive disc with a free anterior margin and a crescent-shaped ventral mouth characterize *G. rufa*. The typical body shape is a relatively thin and long cylindrical structure that is generally rounded in cross section with a complete lateral line, extending along the middle of the depth of the tail. Scales are cycloid and moderate to large (typically 29-36 lateral count). Dorsal fin origin is just anterior to the pelvic fin origin. The number of fin rays varies but typically encountered numbers for the dorsal, pectoral, pelvic, anal and caudal fins are 8, 12-14, 7-8, 5 and 17, respectively. The short gill rakers range from 12-26, while the pharyngeal tooth formula is 2,4,5-5,4,2 or 2,4,4-4,4,2 and the teeth are hooked at the tip (Kara and Alp 2005; Coad 2010).

Considerable colour variation is known to exist in *G. rufa*, as some individuals are pale while others are very dark. Typically, overall color is brownish-olive to dark green with darkly mottled flanks and a yellowish to whitish belly. A dark or bluish-green band runs along the whole flank ending in a spot on the caudal fin base. There is a black, greenish-blue, lime-green or dusky-blue spot behind the upper corner of the gill opening, sometimes extending as a bar to the pectoral fin base. Fins can be yellowish with darker margins, there is a black spot at the caudal fin base, and the upper caudal

lobe may have a few dark grey spots. There is usually a dark spot at the bases of each of the middle four to five dorsal fin rays (Coad 2010).

Total length (TL) of *G. rufa* has been recorded at the following maximal lengths: 13 cm (and a maximum mass of 39 g) for fish collected in Turkey (Kara and Alp 2005) and Iran (Esmaeili and Ebrahimi 2006), 24 cm (and a maximum mass of 129 g) for specimens collected from the Tigris River, Iraq (Rahemo 1995) and 14 cm in fish from Israel (Goren 1974). Yalçin-Özdilek and Ekmekçi (2006) measured 208 *G. rufa* and found a range of 3.3 to 14.5 cm maximum fork length of fish collected during April to November in the Asi River and its tributaries (Turkey).

The diploid chromosome number of *G. rufa* has been reported to vary from 2n = 44 to 52 (Klinkhardt *et al.* 1995; Ergene Gözükara and Çavaş 2004; Esmaeili and Piravar 2007).

DISTRIBUTION

NATIVE DISTRIBUTION AND ABUNDANCE

G. rufa is a sub-tropical species, native to a variety of habitats including rivers, small muddy streams, small ponds and lakes in Eurasia (Froese and Pauly 2010). Its native range includes the Ceyhan, Jordan, Orontes (=Asi), Quwayq and Tigris-Euphrates river basins and coastal drainages of the eastern Mediterranean as well as much of southern Iran (Coad 2010). The global distribution and known collection sites for this species can be viewed in Figures 2 and 3. *G. rufa* is considered a common species across its native range (Coad 2010), for example, it is one of the most widespread species and the most common benthic grazer in the Asi River system (Yalçin-Özdilek and Ekmekçi 2006; Yalçin-Özdilek 2007; Okur and Yalçin-Özdilek 2008) and was the most common fish collected from a system in Southwest Iran (Esmaeili *et al.* 2006). Genetic evidence points toward a genetic divergence among populations from drainages of the Mediterranean and the Persian Gulf (Durna *et al.* 2010).

There is a broad range of climatic conditions within the native range of *G. rufa*, as it inhabits a band from approximately 29 to 40°N. The continental climate within this band ranges from a minimum January air temperature of -10°C at its northern limit to a maximum of 36°C in July at the southern extreme (data generated from IPCC 2010).

NON-NATIVE DISTRIBUTION

G. rufa has not been noted as an exotic species in Canada or elsewhere.

BIOLOGY AND NATURAL HISTORY

REPRODUCTION AND GROWTH

According to Ünlü (2006), *G. rufa* requires clean shallow gravel beds for spawning, which occurs during the May-June period in the Tigris River, Turkey. Alternatively, Bardakci *et al.* (2000) determined that July was the start of the spawning period for females collected from stream and hot spring populations in the province of Sivas in Central Anatolia region, Turkey, based on oocyte development and variation in gonadosomatic index (GSI). Yazdanpanah (2005) determined that the principal spawning period for fish captured in Iran was May but additional spawning was likely to continue into July, based on seasonal changes in the GSI.

Information gained from aquarium-held specimens indicates that *G. rufa* are broadcast spawners, likely over gravel type substrates of which they are most associated, so nest building and egg guarding do not appear to occur with this species (Baensch and Riehl 2004). Other observations derived from aquarium specimens include; juveniles acting as cleaner fish on ectoparasites of other aquarium specimens; propagation in the aquarium environment appears possible; and *G. rufa* is regarded as a novice species, indicating a low degree of difficulty to maintain (Baensch and Riehl 2004). A limited form of external sexual dimorphism may appear in adults at the onset of maturity with the appearance of more pronounced nuptial tubercles in males and the bases of the pectoral, pelvic and anal fins may differ from those of females in breeding males (Coad 2010).

Age of sexual maturity has not been recorded for *G. rufa*, but as individuals have been recorded up to seven years of age (Rahemo 1995), maturity is most likely reached in the first two or three years, which would be in line with other *Garra* species such as *G. rossica* (Coad 2010). The fecundity of *G. rufa* appears to be relatively low compared to other cyprinids with a mean egg count of 761 (range: 184 to 2396) from a total collection of 138 females Iranian specimens (Yazdanpanah 2005).

Growth rates have not been measured in this species but Bardakci *et al.* (2000) recorded average lengths of females studied from hot springs and streams as 73.5 ± 10.6 mm and 97.0 ± 18.4 mm, respectively, while mean body mass was 2.8 ± 0.4 g and 11.2 ± 4.4 g, respectively. Both the hot spring and Topardic stream are closely located in the province of Sivas in Central Anatolia region, Turkey. Environmental conditions for the hot spring fish include high constant temperature (~35°C) and limited food resources, while the stream-based fish experience seasonally fluctuating temperatures (26-34°C in a May to December period) and a more plentiful food supply.

PHYSIOLOGICAL TOLERANCES AND BEHAVIOUR

Okur and Yalçin-Özdilek (2008) defined *G. rufa* as a rheophilic taxa and, in their study measuring fish community structure in Amanos Mountain streams (Turkey), *G. rufa* was the second most common and abundant species of the nine species encountered, present in both perennial and intermittent streams. A total of 18 of the 20 streams in which fish were captured contained *G. rufa*. Environmental conditions of the streams in which *G. rufa* was recorded were observed as follows: largely of coarse substrates, water depths typically ranged from 30 to 50 cm, pH ranged from 7.0-9.0, dissolved oxygen ranging from 6.1-14.8 $mg \cdot l^{-1}$, temperatures ranging from 5.8-31.2°C, water velocities up to 4.5 $m \cdot s^{-1}$, conductivity values ranging from 4.2-36.5 $\mu S \cdot cm^{-1}$ and salinities ranging from 0.10-0.80‰. Yalçin-Özdilek and Ekmekçi (2006) collected *G. rufa* in streams with recorded discharge rates ranging from 1.0-34.5 $m^3 \cdot s^{-1}$.

A Turkish hot spring containing *G. rufa* had a recorded pH of 7.8 with high levels of calcium, magnesium and selenium. The hot spring maintains a mean temperature of about 35°C throughout the year and a mean oxygen concentration of 2.9 $mg \cdot l^{-1}$ (Ozcelik *et al.* 2000). Yet, according to Ünlü (2006), *G. rufa* has a high oxygen requirement; hence, this species tolerance to low oxygen conditions is equivocal.

Additionally, *G. rufa* appear to be able to persist in environments contaminated by heavy metals (Gümgüm *et al.* 1994). Yazdanpanah (2005) studied *G. rufa* in an Iranian stream in which only two other species were encountered, indicating the ability of this species to tolerate poor conditions (listed as pollution, habitat destruction and drought). The Asi River is polluted with wastes from industrial, agrarian and urban

activities; eutrophication resulting from the input of these various contaminants may result in favourable alga growth, important as a food source for *G. rufa* (Yalçin-Özdilek and Ekmekçi 2006).

FEEDING AND DIET

G. rufa is known to adhere by suction to rocks with its ventral crescent-shaped mouth to feed on benthic plant material. Gut content analysis on fish caught in the Asi River and its tributaries (Turkey) has revealed that these fish feed mainly on benthic plant material dominated by cyanobacteria, Chrysophyta and Chlorophyta, with Chrysophyta being most common (*Navicula* sp. and *Gomphonema* sp. were most abundant and frequent); rotifers and protozoa have also been recorded (Yalçin-Özdilek and Ekmekçi 2006) (Table 1). Juvenile gut content was dominated by chrysophytes while, in older individuals, cyanophytes and chlorophytes became more common. The authors determined that both season and location in the stream affected the composition of the diet but season was the most important factor. Larval feeding and nutritional requirements are largely unknown and in need of further exploration.

HABITAT

G. rufa is a bottom dweller that can be found in different freshwater habitats such as rivers, small muddy streams, small ponds and lakes hiding under and among stones and vegetation (Krupp and Schneider 1989). Goren and Ortal (1999) comment that this species depends upon rocky habitats in Lake Kinneret, Israel.

INTERSPECIFIC INTERACTIONS

As *G. rufa* is unknown as an exotic species, direct observation or measurement of ecological impact is uncertain. Due to the modest size and largely herbivorous tendency of *G. rufa*, it may be in competition for food resources with resident species that live in compatible habitats and have similar dietary requirements and feeding habits, such as suckers and certain cyprinids (Brian W. Coad, Canadian Museum of Nature, 240 McLeod Street Ottawa, ON "pers. comm.").

Suggested predators of *G. rufa* include the European Eel (*Anguilla anguilla*) and catfish (e.g., *Clarias gariepinus*) (Yalçin-Özdilek 2007) and other piscivorous cyprinids,

such as *Aspius vorax* (Coad 2010) and *Carasobarbus canis* (Spataru and Gophen 1985). *G. rufa*, like most other cyprinids, have few defences and can be expected to be susceptible to predation by a variety of animals at all stages of life. The Western Mosquitofish (*Gambusia affinis*) may have caused the extirpation of *G. rufa* from the Qishon River basin, the largest coastal river in Israel (Goren and Galil 2005). A loss of shelter due to eutrophication and modification of the riverbed for flood prevention deprived the larvae and post-larvae of shelter and exposed them to Western Mosquitofish predation.

DISEASES AND PARASITES

Various *Dactylogyrus* spp. monogeneans have been recorded from the gills of *G. rufa* (Jalali and Molnár 1990; Gussev *et al.* 1993), *Gyrodactylus* spp. have also been noted (Jalali *et al.* 2005). *Cucullanus* (Nematoda) infection has been recorded in the pericardium of *G. rufa* (Moravec and Rahemo 1993; Rahemo 1995) and small-sized nematode larvae (of the family Cucullanidae) encysted in the pericardium and parasitic nematodes have also been observed in this species (Yalçin-Özdilek and Ekmekçi 2006). Furthermore, Rahemo (1995) recorded a parasitic crustacean (*Pseudolamproglena annulata*) infecting the gills and a digenea (*Pseudochetosoma salmonicola*) infecting the gall bladder of *G. rufa*.

USE BY HUMANS

PSORIASIS CONTROL AND SPA INDUSTRY

G. rufa have been utilized in psoriasis treatment (e.g., Ündar *et al.* 1990), originally known from the Kangal hot springs in Central Anatolia, Turkey. Increasingly common is the use of this species by the spa industry for pedicures and manicures; operations are opening up in U.S.A and Canada. For both applications, the fish feed on dead skin.

USE AS HUMAN FOOD

Garra species may be occasionally fished and consumed (Coad 2010).

CONSERVATION STATUS

G. rufa tends to be a common species with a wide distribution and is not thought to be under any specific threat (Coad 2010) but is listed as vulnerable in Turkey (Fricke *et al.* 2007) due to a significant regional decline resulting from a myriad of human disturbances.

SUMMARY

Information concerning the description, distribution, life history and biology of *G. rufa*, along with its uses by humans and interactions in aquatic ecosystems, was compiled. This species is relatively small (typically less than 15 cm) and short-lived. Briefly, *G. rufa* has been recorded in a wide range of water temperatures (5.8-35°C) and appears capable of tolerating degraded systems. Although its spawning characteristics are not well studied, it appears to be a broadcast spawner that affords no parental care with a spawning season that runs from late spring into summer. It is a generalist feeder but periphyton tends to make up the majority of its diet. *G. rufa* is a bottom dweller resident to a variety of habitats but it appears most often in lotic environments. It also occurs in hot springs where it feeds on the skin scales of bathers, reducing illnesses such as neurodermitis. This feeding behaviour has piqued the interest of the spa industry in North America, where the fish is being imported to be utilized in a novel form of pedicure and manicure service.

ACKNOWLEDGEMENTS

Helpful information was provided by Brian Coad (Canadian Museum of Nature). The author is grateful for the efforts of Rachel Auclair at the CCIW library for tracking down some of the more difficult to acquire publications. Funding was provided by CEARA.

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Table 1. Percentage contribution of food item groups in *Garra rufa* diet (N – % abundance, F – % frequency of occurrence; modified from Yalçin-Özdilek and Ekmekçi 2006).

	Food Items Category	N	F
Cyanobacteria N = 10 F = 40.9	*Chroococcus* sp.	< 0.1	1.5
	Anacystis sp.	< 0.1	1.5
	Merismopedia sp.	< 0.1	1.5
	Dactylococcpsis sp.	2.1	4.6
	Tetrapedia sp.	< 0.1	1.5
	Oscillatoria sp.	7.8	36.4
Chrysophyta N = 81.4 F = 97.0	*Synedra* sp.	0.2	6.1
	Melosira sp.	0.9	12.1
	Achnanthes sp.	0.4	1.5
	Amphora sp.	0.5	12.1
	Fragilaria sp.	0.1	3.0
	Diatoma sp.	0.7	1.5
	Gyrosigma sp.	0.3	7.6
	Gomphonema sp.	17.3	63.6
	Cocconeis sp.	2.1	31.8
	Nitzschia sp.	12.0	42.4
	Navicula sp.	34.2	66.7
	Rhoicosphenia sp.	1.4	27.3
	Cyclotella sp.	5.9	39.4
	Cymatopleura sp.	1.4	9.1
	Pinnularia sp.	< 0.1	1.5
	Cymbella sp.	4.0	39.4
	Surirella sp.	0.2	6.1
Chlorophyta N = 8.1 F = 40.9	*Selenastrum* sp.	0.1	6.1
	Coelastrum sp.	0.2	7.6
	Staurastrum sp.	< 0.1	3.0
	Dictyosphaerium sp.	< 0.1	1.5
	Stigeoclonium sp.	0.3	6.1
	Actinastrum sp.	< 0.1	1.5
	Westella sp.	< 0.1	1.5
	Crucigenia sp.	0.6	7.6
	Tetrastrum sp.	< 0.1	1.5
	Excentrosphaera sp.	0.5	1.5
	Tetraedron sp.	0.1	4.6
	Nautococcus sp.	< 0.1	1.5
	Asterococcus sp.	< 0.1	1.5
	Chlorococcum sp.	0.4	3.0
	Scnedesmus sp.	5.1	37.9
	Cladophora sp.	0.2	3.0
	Chaetophora sp.	0.2	3.0
	Pediastrum sp.	0.4	13.6
Protozoa		0.4	4.6
Nematoda		< 0.1	3.0
Rotifera		< 0.1	1.5

a)

b)

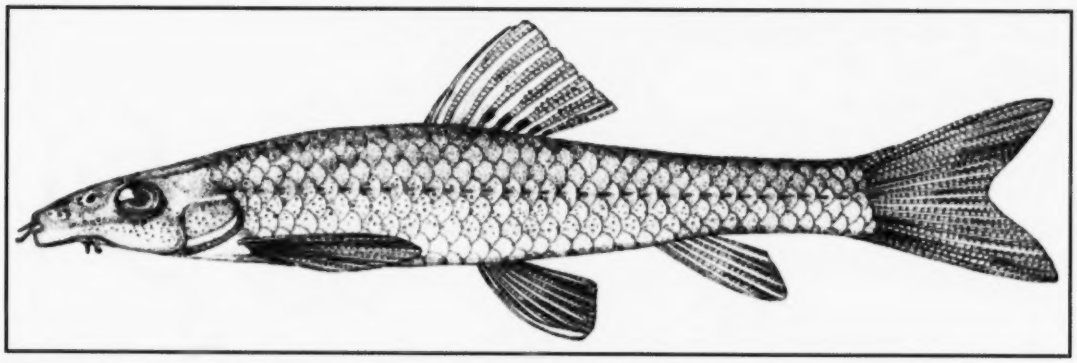

Figure 1. Doctor Fish (*Garra rufa*). a) live specimen from Jordan (copyright: Koji Kawai; Froese and Pauly 2010) and, b) stipple drawing (copyright: Brian W. Coad, Canadian Museum of Natural History; Coad 2010).

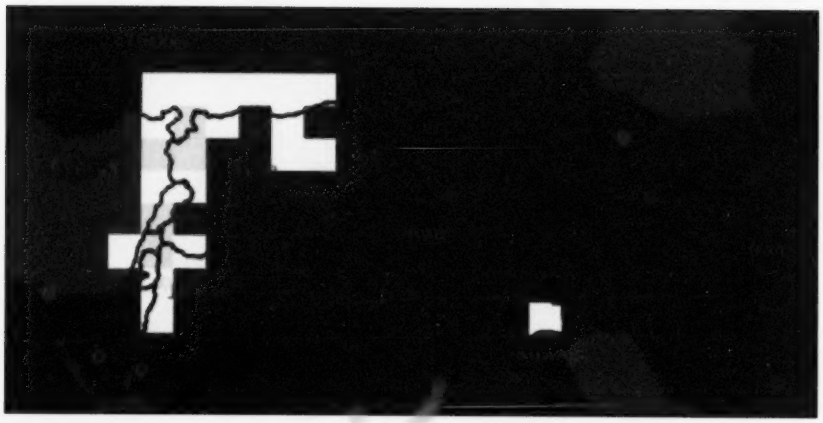

Figure 2. Global distribution of *Garra rufa* records where count / one degree cell equals ☐ 1-9 ☐ 10-99 (GBIF 2009).

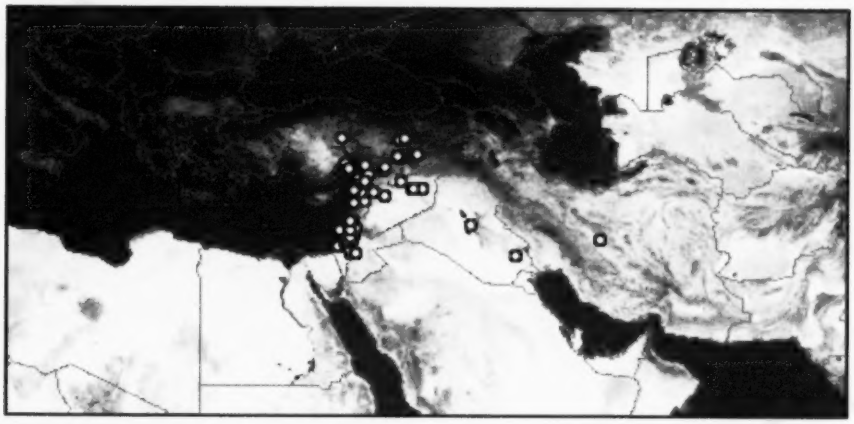

Figure 3. Recorded *Garra rufa* collection sites (Discover Life 2010).